Redfield-pseudomodes theory

Quantum systems which are strongly coupled to a large environnement or a bath are difficult to tackle theoretically, since common approximations such as weak-coupling Master equations break down in this regime. A commonly used concept to circumvent this difficulty is to include the bath degrees of freedom responsible for the strong coupling into the system. This idea underlies a whole family of approaches known as pseudomodes theory, whose most well-known representative is the open Jaynes-Cummings model. In general, pseudomodes are an approach to describe the dynamics of open quantum systems where instead of tracing out the complete environment, discrete auxiliary modes featuring Lindbladian loss are retained in the system. We present a generalized pseudomodes concept which allows for more general Markovian loss described by a Redfield equation. We then apply the generalized Redfield-pseudomodes approach within the framework cavity quantum electrodynamics. In particular, we derive a pseudomodes expansion of the spectral density, which has to be matched with the original continuum theory to guarantee the equivalence of the Redfield-pseudomodes representation. We then compare the fitting capability of the generalized mode expansion of the spectral density to that of the corresponding expansion in the Lindblad-pseudomodes representation for different exemplary cavity geometries, demonstrating a significantly improved convergence of the fit.